

MARS EXPLORATION PLANNING

Tamara L. Dickinson
National Aeronautics and Space Administration
Washington, DC 20546

Mars Exploration Planning



- Mars Observer
- MESUR
- Small Rovers and Sample Return Missions

Mars Exploration Planning



➤ Mars Observer

MESUR

Small Rovers and Sample
Return Missions

Mars Observer: Mission Rationale



While Knowledge of Mars is Extensive, It Contains Significant Gaps. More Importantly, There Are a Number of First Order Scientific Questions That Can be Best Addressed From an Orbital Platform. The Geoscience/Climatology Orbiter Will Provide New Observations and Complement Existing Measurements, and Provide an Improved Basis for Future Intensive Investigations.

SSEC Report

Mars Observer



- Low Altitude Polar Orbit
- 1 Martian Year Mission Duration
- Simple Repetitive Geological/Climatological Mapping Mission
- Spacecraft Based on Derivative of Earth Orbital Spacecraft
- Experiments Selected Concurrent with Spacecraft

SCIENCE OBJECTIVES

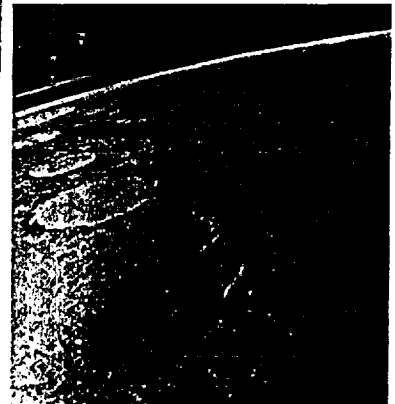
MARS OBSERVER WILL . . .

DEFINE GLOBALLY THE TOPOGRAPHY
AND GRAVITATIONAL FIELD



DETERMINE THE GLOBAL ELEMENTAL
AND MINERALOGICAL CHARACTER
OF THE SURFACE MATERIAL

DETERMINE THE TIME AND SPACE
DISTRIBUTION, ABUNDANCE, SOURCES,
AND SINKS OF VOLATILE MATERIAL AND
DUST OVER A SEASONAL CYCLE



EXPLORE THE STRUCTURE AND
ASPECTS OF THE CIRCULATION
OF THE ATMOSPHERE

ESTABLISH THE NATURE
OF THE MAGNETIC FIELD

Mars Observer



Science Instrument Measurement Objectives

Gamma Ray Spectrometer

Elemental Composition of Surface

Magnetometer

Intrinsic and Local Magnetic Field

Mars Observer Camera

Global Synoptic Views, Selected Moderate and Very
High Resolution Images of Surface and Atmosphere

Pressure Modulator
Infrared Radiometer

Profiles of Temperature, Water, Dust, and Radiation
Budget Measurements

Radar Altimeter

Topography, Microwave Radiometry

Radio Science

Gravitational Field; Atmospheric Refractivity Profiles

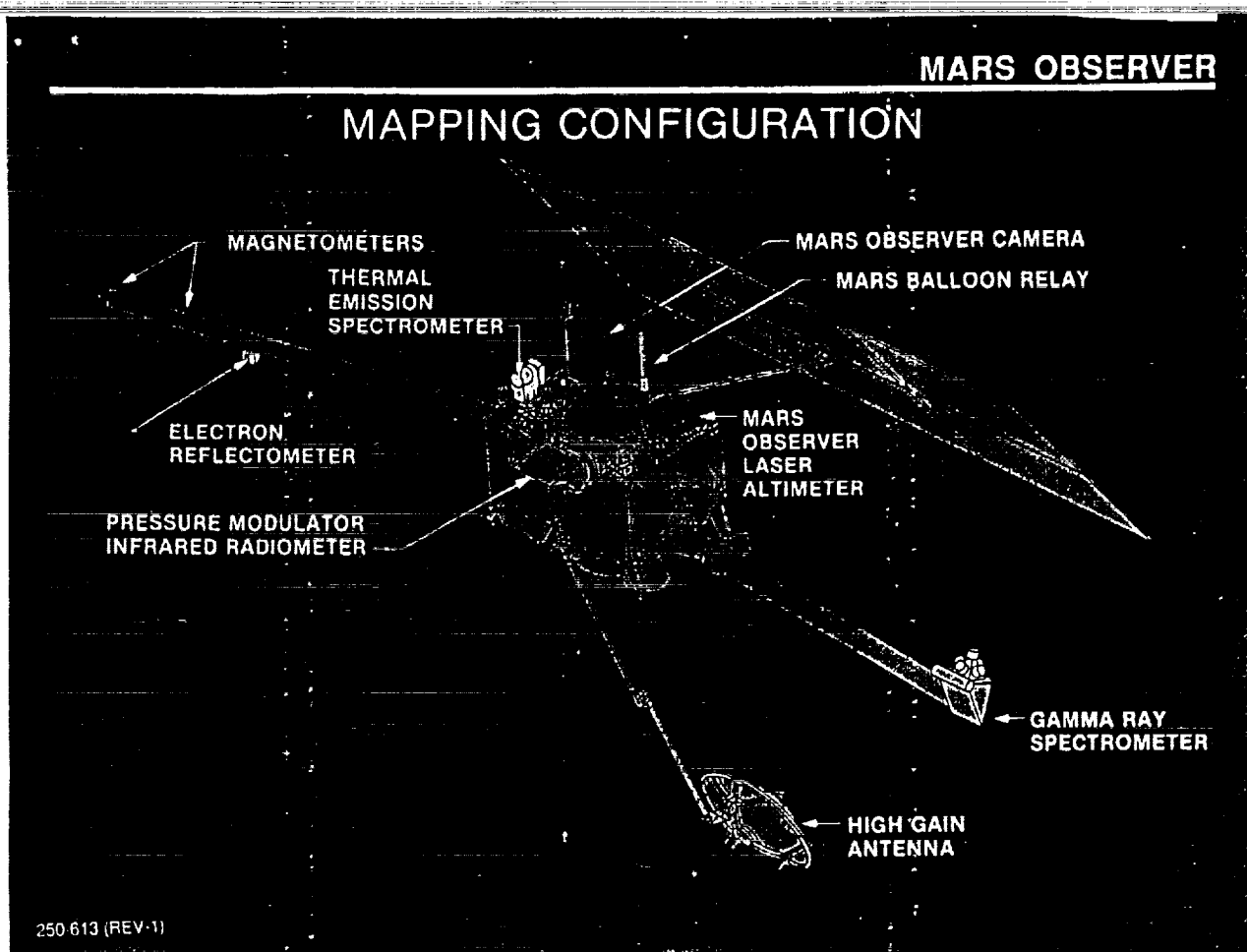
Thermal Emission
Spectrometer

Surface Mineralogy; Atmospheric Dust and Clouds:
Radiation Budget

Mars Observer Status



- Spacecraft Assembly and Test Nearing Completion
- Five of 7 U.S.-Supplied Instruments Delivered and Integrated
 - Remaining 2 to be Delivered in February
 - Gamma-Ray Spectrometer Electrically Integrated with Spacecraft and Functional Testing Completed
 - Excellent Instrument Performance
 - Thermal Emission Spectrometer Successfully Completed Acceptance Tests and Was Delivered
 - Pressure Modulator Infrared Radiometer (PMIRR) Integrated Systems Testing Successfully Completed



Mars Observer Status



- Instrument and Spacecraft Integration and Test Schedules Remain Challenging
 - Mars Balloon Relay Delivered and Integrated
 - Mars Observer Camera Electronics Completed and System Performance Testing Underway
- All Titan III Major Design Reviews Completed
 - TOS Completed and in Storage
 - Launch Complex Behind Schedule, but on Recovery Plan

Mars Exploration Planning



Mars Observer

➤ MESUR

Small Rovers and Sample Return Missions

MESUR Philosophy



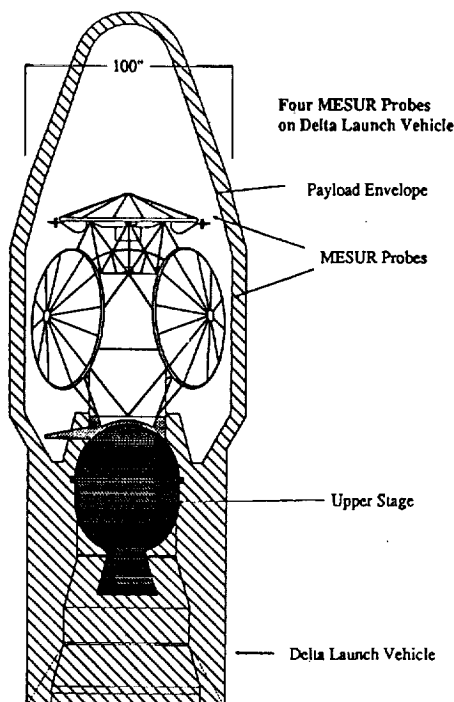
- "Grow" a Survey Network Over a Period of Years (a Series of Launch Opportunities)
- Develop a Level of Effort Which is Flexible and Responsive to a Broad Set of Objectives
- Focus on Science Return While Providing a Solid Basis for SEI (e.g., Site Selection Data)
- Minimize Cost and Complexity Wherever Possible

Baseline Mission Profile

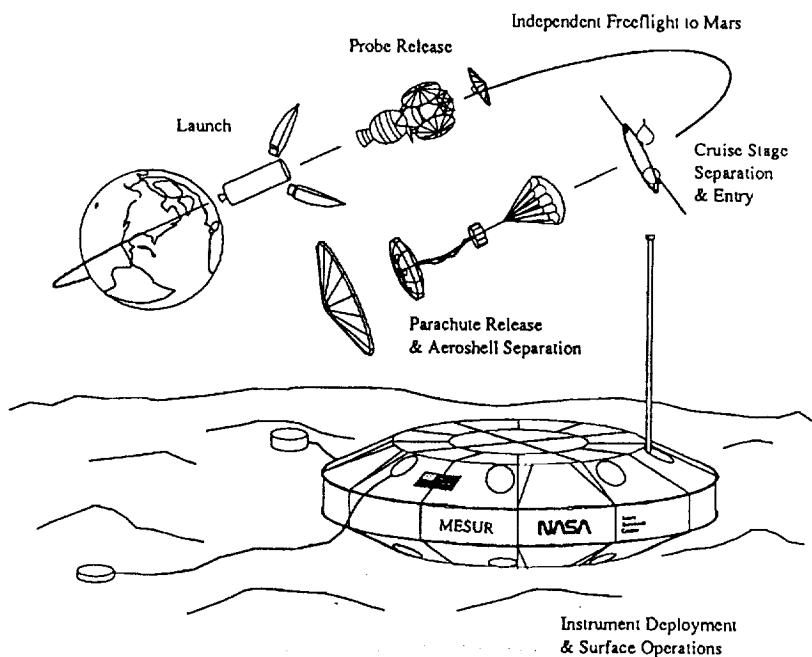


- 16 Landers
- Delta II Launches at Every Opportunity
 - 2001, 2003, 2005
 - 4 Probes per Launch
- Small Free-Flyer Spacecraft, Spin Stabilized
 - Probes Designed as Cruise Stage, Entry System, Lander
 - Design Based on Pioneer & Viking Heritage
 - "Hard" Landing of <40 g's
 - RTGs
 - Communications Orbiter
 - Launch 2003

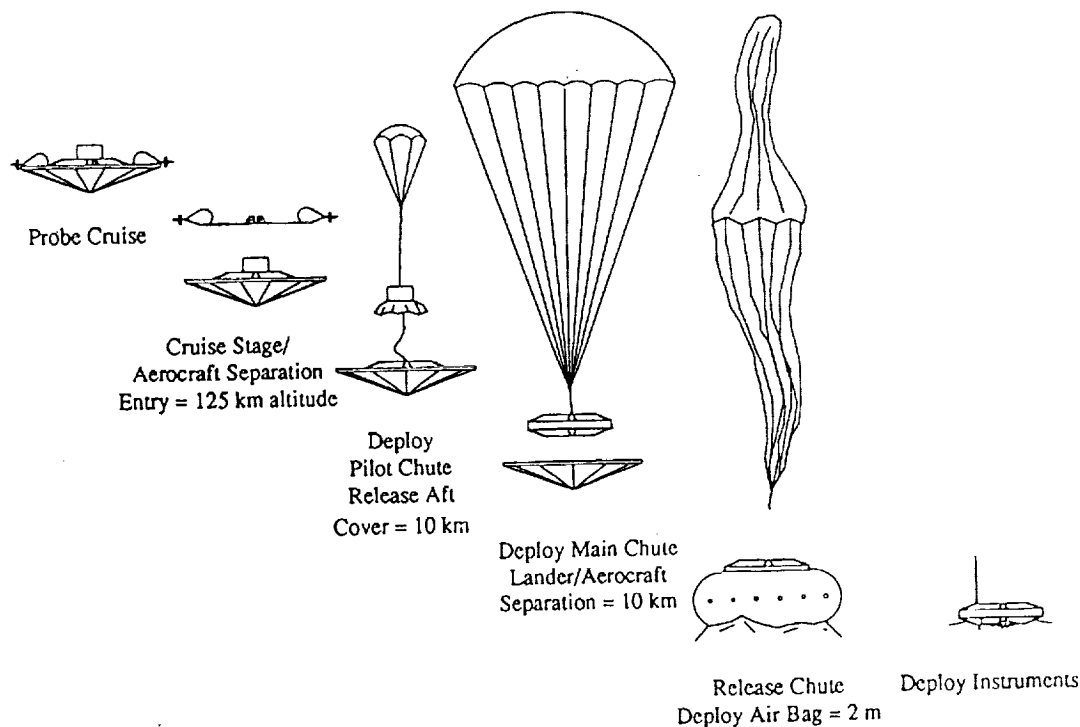
Launch Configuration



MESUR Mission Summary



MESUR Descent and Deployment

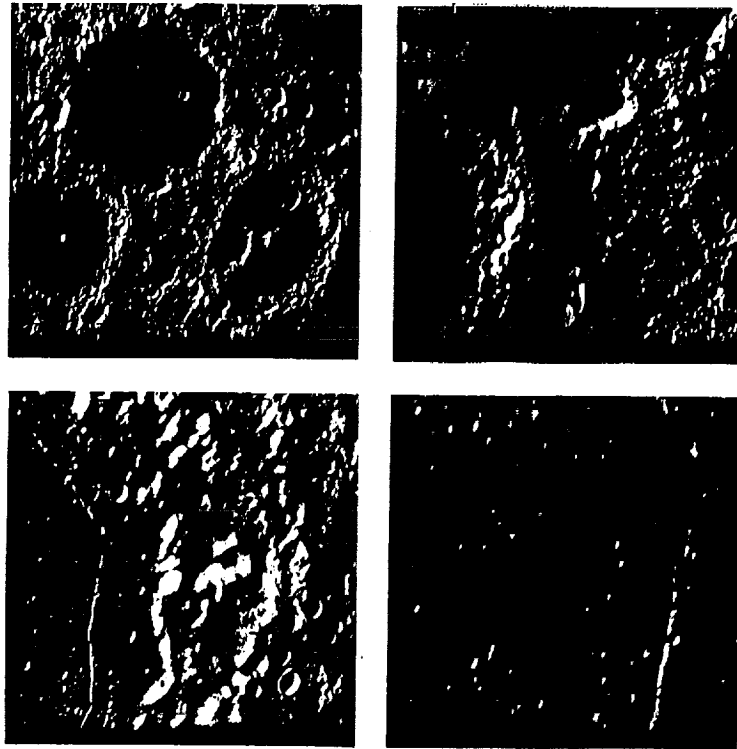


Detailed Mission Objectives and Assumptions from MarsSWG



- **Descent and Surface Imagery (Multiband)**
 - Nested Images Desirable but Not Required
- **Landing Accuracy on the Order of 100 km**
 - Knowledge of Relative Lander Position to 1 km
- **Entry Science Performed**
 - Atmospheric Structure Experiment

RANGER DESCENT IMAGING



Descent Imaging Concerns

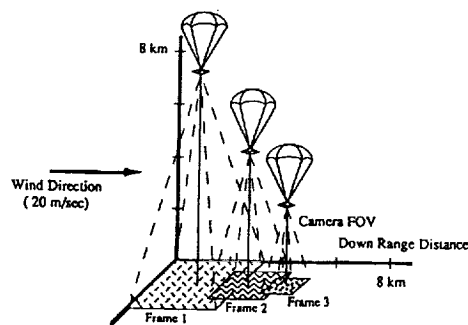
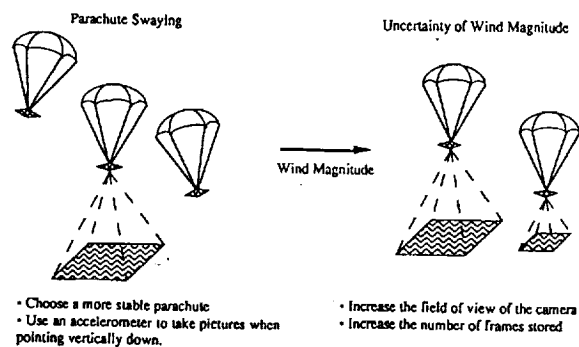


Figure V-2. Descent Imaging Concept



Detailed Mission Objectives and Assumptions from MarsSWG



- **Meteorology Measurements**
 - Long Station Life (Simultaneous Measurements for 1-3 Mars Years)
 - Large Number of Widely Dispersed Stations (15-20)
 - Pressure, Opacity, Temperature, Winds and Humidity if Possible

Detailed Mission Objectives and Assumptions from MarsSWG



- **Seismology Measurements**
 - Short Period Seismometer, Single 3-Axis, as Broad Band as Possible
 - Surface Emplaced Seismometer
 - Long Station Life (>1 Mars Year)

Detailed Mission Objectives and Assumptions from MarsSWG



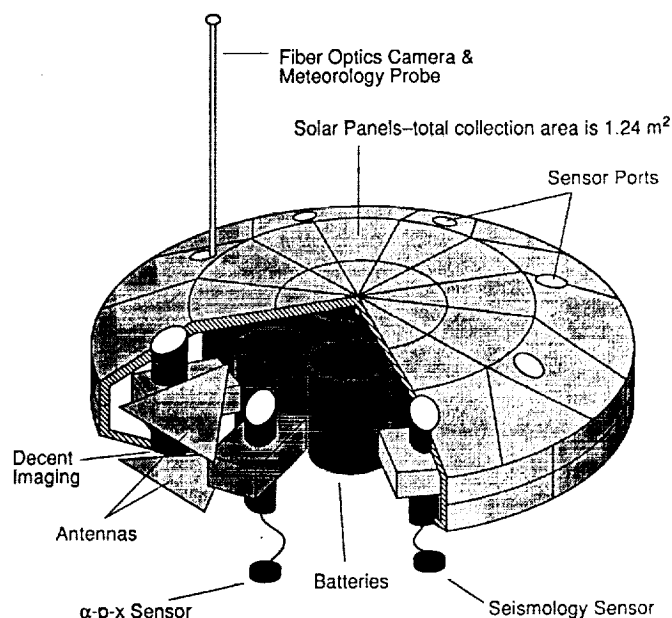
- **Geochemistry Measurements**
 - Instruments Placed on Surface
 - Elemental Composition Instrument (α -p-x) Deployed at Each Station
 - Thermal Analyzer and Simple Evolved Gas Analyzer

Strawman Lander Science Payload



- Atmospheric Structure Experiment
 - Determination of Winds
- Descent/Surface Imager (CCD/CID Array)
- Meteorology Package
 - Atmospheric Pressure
 - Atmospheric Opacity
 - Temperature, Humidity, and Winds (at 1m Above Lander)
- Surface Composition (α -p-x)
- Seismometer
- Impact Accelerometer
- Thermal Analysis Instrument (e.g., DSC)

MESUR Lander



MESUR Strawman Science Payload



INSTRUMENT	MASS (kg) *	POWER (W)	DATA	DIMENSIONS (cm)	LATITUDE DEPENDENCY	HERITAGE	MAX. LOAD (peak)	OPERATIONS DUTY CYCLE
METEOROLOGY PACKAGE Note (1)	0.66 *	0.021	10 kbits per day	Not Available		NEW	<40	continuous - wind, temp point measure- ments, humidity, pressure continuous
3-AXIS SEISMOMETER (Sensor package)	1.5 * Note 2	2	10 Mbits/day			NEW		
ATMOSPHERIC STRUCTURES INSTRUMENT, Note (1)	1.5	6.2	65 bps	4 x (5-10) long (5 sensors) 10 x 13 x 13 (elec box)	Note (1)	Galileo, PV, Viking	<500	5.5 minutes
ELEMENTAL COMPOSITION INSTRUMENT, (alpha/proton/x-ray)	0.6 *	0.5	100 kbits for 3 spectra	need elec dimensions (4.5 x 3.2)	primarily site dependent	NEW, Viking	<40	600 minutes
IMAGERS:								
DESCENT	0.22 *	4	12 Mbits to store 12 images	6 x 6 x 3 (head) 10 x 10 x 3 (internal elec)		NEW	<40	continuous during descent
SURFACE	1.34 *	21	25 Mbits per 360 deg scan	10 x 15 x 6 (camera/drive) 1000 x 1 dia (Mast) 3 x 2 x 5 (head)		NEW	<40	10 minutes
COMMON ELECTRONICS	0.26	Note 3		Included w/ imagers		NEW		Included w/ imagers
THERMAL ANALYZER & EVOLVED GAS ANALYZER	2	12	3M bits per sample	12 x 12 x 12	primarily site dependent	NEW	<40	60 minutes (4 samples per martian year)
TOTAL	8.10							

Notes:

* mass estimate does not include deployment hardware

(1) may share common sensor

(2) mass estimate for sensor only

(3) mass estimate included in descent and surface imagers mass estimate

Mars Exploration Planning



Mars Observer

MESUR

➤ Small Rovers and Sample Return Missions

Science Drivers: Sample Return Mission



- Return Martian Samples to Earth Laboratories for Analysis
 - Highest Priority Science Objective for Mars
- Geology of Mars
 - Based on Geologic Mapping from Viking Images (Defined Units kms Scale)
- Defined 10 Different Units
 - Need ~10 Different Types of Samples Returned

Science Drivers: Sample Return Mission



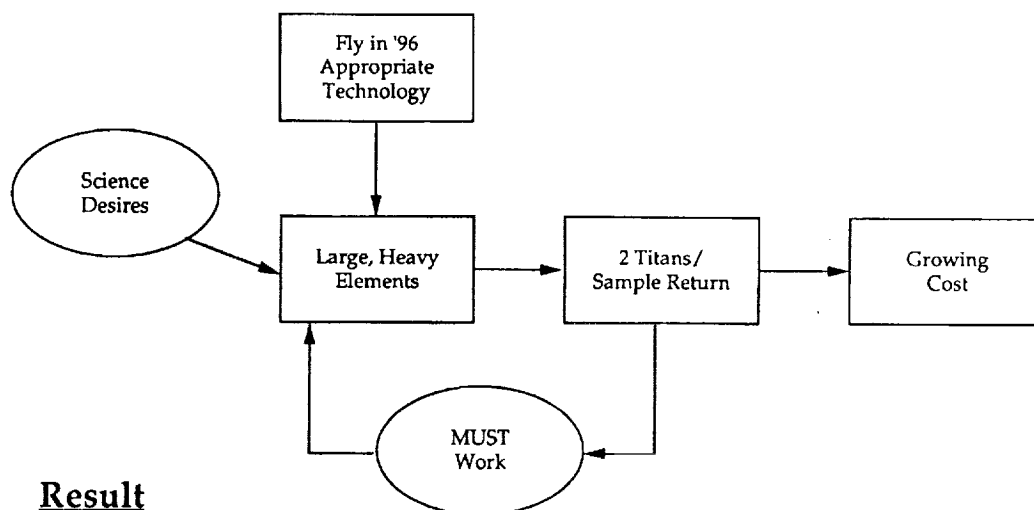
Heavily Cratered Material → Early History of Planets

Volcanic Rocks → Age and Composition of Planet

Sedimentary Rocks → Climatologic and Biologic (?) Conditions

Drift Material, Soil, Salts, Ice, Atmosphere → Volatile Inventory

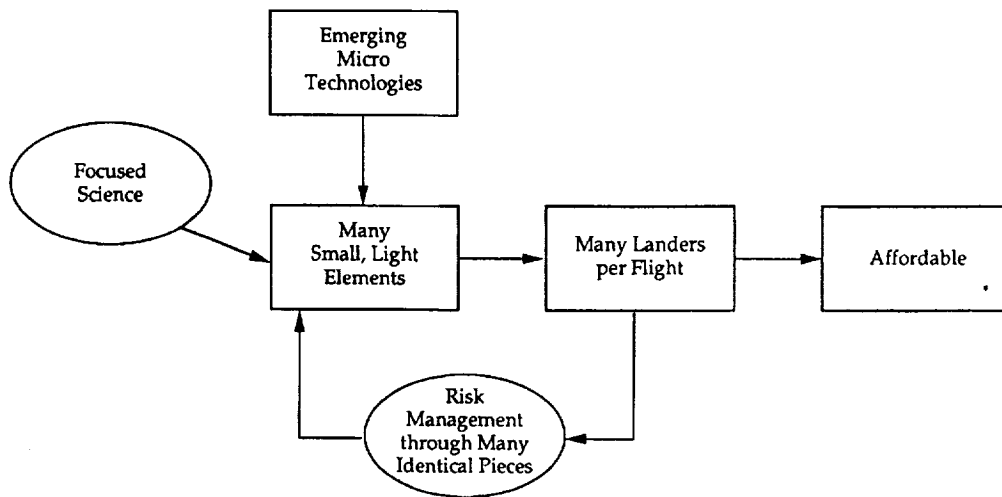
MSRS "Old Think"



Result

- Many interacting elements, complex operation
- Extremely Capable Rover
- Two Titan 4 Launches for One Sample Return
- Risk management through very high reliability, single items
- Cost ~\$10B

Micro Technology Based Approach "New Think"



Result

- Much smaller pieces - few on a Delta or Atlas
- Risk Management through many tries
- Cost goal ~\$1.5 - 2 B

Key Concepts to "New Think"



- Take Advantage of Emerging Micro Technologies
 - Most Develop Outside NASA, Particularly for SDI
 - Includes Integrated Electronics, Power, Processors, Propulsions, Software...
- Focused Science
 - Limited Access from Lander and Constrained Landing Regions
 - Less Capable Rover
 - Less Elaborate Sampling
 - Less in-situ Science
 - No Traverse Science
 - Less Stringent Sample Preservation

Key Concepts to “New Think”



- Simplify Missions to Absolutely Essential Elements
- Commit to Many Small Landers
 - Accept that Some Fraction (~20%?) Will Fail
 - Manage Risk by Increased Number of Independent Landers
 - Mission Success Achieved with a Fraction (<1) of Landers Successful

Comparison of Approaches



- Returned Samples
 - Both ~8-10 Different Sample Types
 - Similar Total Mass
 - MRSR Samples from 2 Areas
 - Small SR Samples from Diverse Areas

Comparison of Approaches



- Rovers/Landers
 - MRSR
 - Large Complex Rover
 - Many in-situ Instruments on Rover
 - Traverse Science
 - Sample Packaging/Preservation on Rover
 - Small SR
 - Small Simple Rover
 - No Traverse Science
 - Most in-situ Instruments on Lander
 - Sample Preparation on Lander
 - Different Instruments on Different Landers

Small SR



- Satisfies All Major Science Objectives
- Simple Approach
- Flexible
- Less Expensive
- Failure Tolerant

Key Technologies



- Mini RTGs
- Advanced Propulsion Systems
- Small Rover 'Behavior' Control
- Micro Sensors and Instruments
- In-situ Instruments
- Micro Spacecraft Subsystems
- Long Life Electronics

Small Rover Mission Strategies



- Many Landing Options (Propulsive Lander to Ranger-Style Impact Capsule)
- Use Beacons and INS to Guide Rovers
- Reliability Through Redundancy
- Many Small Rovers Mean Smaller Traverses and Shorter Required Lifetimes
- Many Landings Allow Rovers to be Targeted at Individual Geologic Units

Mission Options



- **Direct Return from Surface to Earth Entry**
 - No Sample Transfer After MARV Lift-off
 - JPL Design Emphasis
- **Mars Orbit Rendezvous**
 - Sample Transfer MAV to ERV/SRC in Mars Orbit
 - Previous JSC Design Emphasis
- **Earth Orbit Rendezvous**
 - Sample Transfer MARV to ERV/SRC in Earth Orbit
 - Martin Marietta Corporation Design Emphasis

Micro MAV Sample Return Options



Option Design	Direct Return Current JPL	Mars Orbit Rendezvous Old JPL/JSC	Earth Orbit Rendezvous Current MMC
MARV Mass	380 kg	62	311
MARV Delta-V	6339 m/s		7235
Sample Mass	0.5 kg	0.5	0.5
Other Elements	SRC+Lander+Aeroshell+Minirover	Lander+Aeroshell+Minirover	Lander+Aeroshell+Minirover
Flight System Mass	(6 elements) 790 kg	(5 elements) 230	(5 elements) 715
Aeroshell Diameter	3.6 m	2.0	3.7
Beta	46 kg/m ²	46	41
Launch Vehicle	Atlas IIAS (4)	Delta 7925 (4)	Atlas IIAS (4)
C3	11.1 km ³ /s ² (2009)	17.7 (2005)	11.1 (2009)
Flight Systems per Launch	2	2	2
Mass Margin	20%	85%	33%
Other Launched Elements	CO+Delta (2)	R/CO+Atlas (2) SRC+ERV+Delta (4)	CO+Delta (2) SRC+ERV+Delta (3)

Interactions with SEI



- **New Associate Administrator Named**
- **Huntress/Griffin Agree on Science Objectives and Priorities for Moon and Mars**
- **Who Will Implement Moon/Mars Missions?**
- **Discussions Continue**